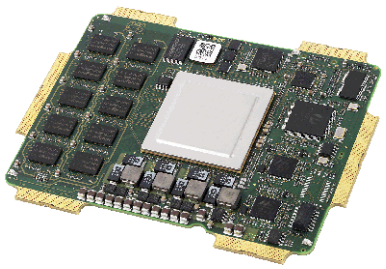
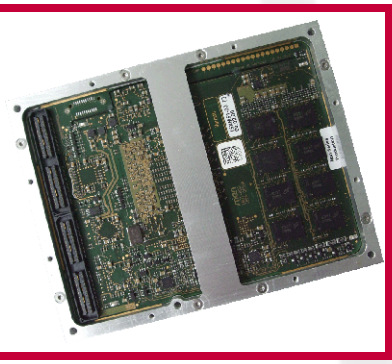
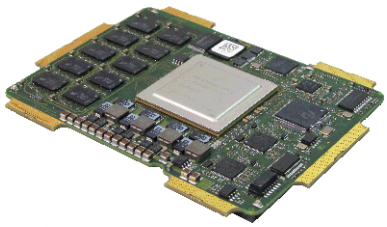
User Manual

XM51 – ESMexpress® COM with PowerPC® QorIQ™ P4080



Module without cover and frame





XM51 - ESMexpress® COM with PowerPC® QorIQ™ P4080

The XM51 is a multi-core computer-on-module based on the Freescale™ PowerPC® QorIQ™ family. Together with an application-specific carrier board it forms a semi-custom solution for industrial, harsh, mobile and mission-critical environments.

The XM51 is built around a QorIQ™ P4080, P4040 or P3041 running at frequencies between 1.2 and 1.5 GHz. All types have multi-core performance and advanced processing functions (incl. encryption), but the XM51 is still scalable to individual needs. The eight-core P4080 is a high-end number cruncher, while the P3041 aims at power and cost efficiency. The entire board draws a maximum power of 32 W and supports extended operating temperatures in all configurations.

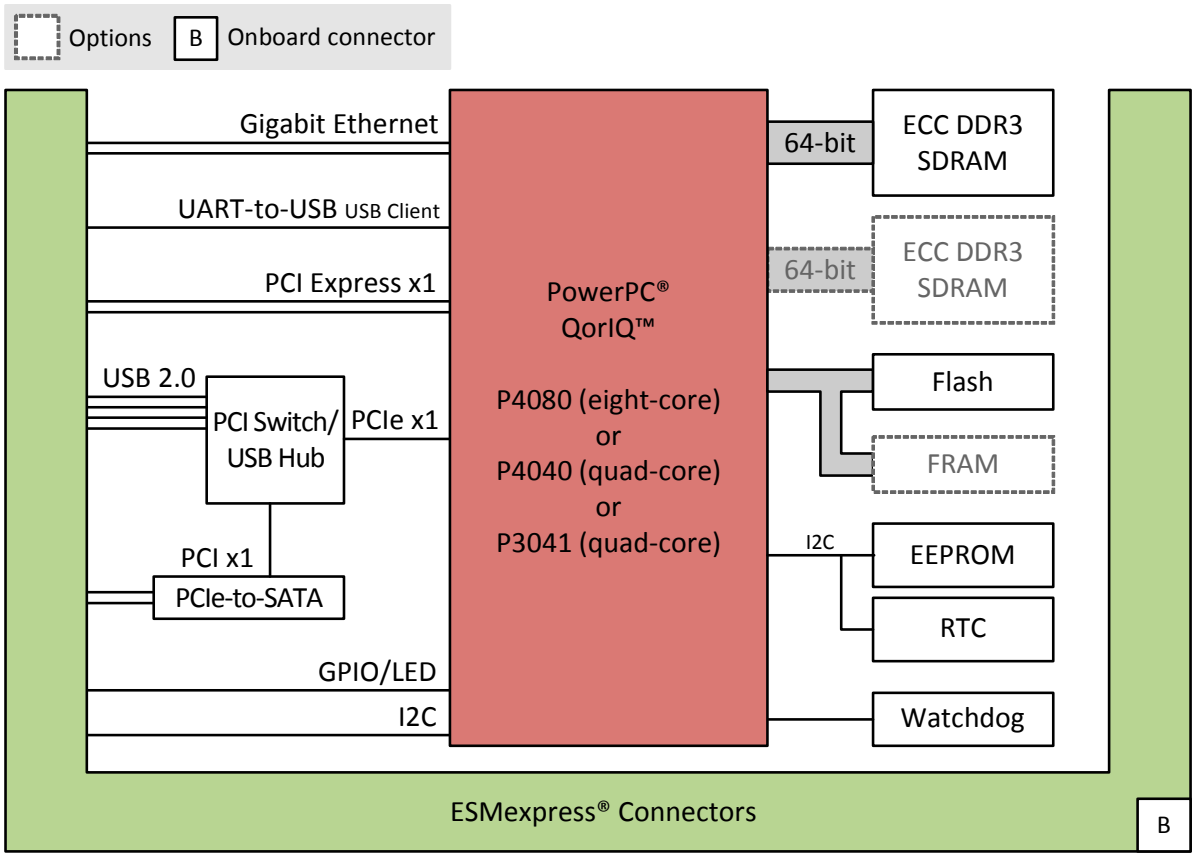
The COM has up to 16 GB of soldered ECC main memory driven by two independent controllers. The two RAM banks can be assigned to processor cores to avoid access conflicts and assure deterministic behavior. This facilitates building up certifiable solutions for safety-critical avionics or railway applications. Up to 512 KB industrial, non-volatile FRAM and 256 MB Flash round out the XM51's onboard memory. Further capacity can be added on the carrier board as needed via high-speed serial busses, i.e. USB or SATA.

All interfaces routed from the QorIQ™ processor are available on any ESMexpress® carrier board. Those include four USB 2.0 host ports and one USB client realized using a UART-to-USB converter, two Gigabit Ethernet channels, dual 3-Gbit SATA, and two PCI Express® x1 links. The latter support PCIe® 2.x with data rates of 5 Gbit/s per lane.

The XM51 is qualified for operation in a -50°C to +85°C conduction or convection cooled environment. As all ESMexpress® modules it is embedded in a covered frame. This ensures EMC protection and allows efficient conductive cooling. Air cooling is also possible by applying a heat sink on top of the cover. ESMexpress® modules are firmly screwed to a carrier board and come with rugged industry-proven connectors supporting high frequency and differential signals. Only soldered components are used to withstand shock and vibration, and the design is optimized for conformal coating. All ESMexpress® modules support a single 95 x 125 mm form factor.

For evaluation and development purposes an ATX carrier board is available. The ESMexpress® module can be evaluated on a COM Express® carrier board via an adapter from ESMexpress® to COM Express®.

Diagram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B
Onboard connector
Gigabit Ethernet
UART-to-USB USB Client
PCI Express x1
USB 2.0
PCI Switch/
USB Hub
PCIe x1
PCI x1
PCIe-to-SATA
GPIO/LED
I2C
PowerPC®
QorIQ™
P4080 (eight-core)
or
P4040 (quad-core)
or
P3041 (quad-core)
64-bit
ECC DDR3
SDRAM
64-bit
ECC DDR3
SDRAM
Flash
FRAM
I2C
EEPROM
RTC
Watchdog
ESMexpress® Connectors
B

Technical Data

CPU

- Freescale™ QorIQ™ P4080 or P4040 or P3041
  - 1.2 GHz up to 1.5 GHz
  - Eight/four high-performance Power Architecture e500mc cores

Memory

- 32 KB instruction and data L1 cache and private 128 KB L2 cache per processor core
- Up to 16 GB SDRAM system memory
  - Soldered
  - DDR3 with ECC support
  - Up to 667 MHz memory bus frequency, depending on processor configuration
  - P4080/P4040 with two independent memory controllers, P3041 with one controller
- Up to 256 MB boot/program Flash
- 128 KB non-volatile FRAM
- Serial EEPROM 8 kbits for factory settings

Serial ATA (SATA)

- Two ports via ESMexpress® connector
- SATA Revision 2.x support
- Transfer rates up to 300 MB/s (3 Gbit/s)
- Via PCIe®-to-SATA bridge

USB

- Four USB 2.0 host ports via ESMexpress® connector
  - OHCI and EHCI implementation
  - Data rates up to 480 Mbit/s
- One USB client port via ESMexpress® connector
  - Via UART-to-USB converter
  - Data rates up to 230.4 kbit/s
  - 16-byte transmit/receive buffer
  - Handshake lines: none

Ethernet

- Two 10/100/1000Base-T Ethernet channels
- Two LED signals per channel for LAN link and activity status and connection speed
- Accessible via ESMexpress® connector

PCI Express®

- Two x1 links via ESMexpress® connector
- PCIe® 2.x support
- Data rate 500 MB/s in each direction (5 Gbit/s per lane)

GPIO

- 3 lines via ESMexpress® connector

I2C Bus

- 1 interface via ESMexpress® connector

Miscellaneous

- Real-time clock (with supercapacitor or battery backup on the carrier board)
- Temperature sensor, power supervision and watchdog

Electrical Specifications

- Supply voltage/power consumption:
  - +12V (9..16 V), 32 W max.

Mechanical Specifications

- Dimensions: 95 mm x 125 mm (conforming to ESMexpress® specification)
- ESMexpress® PCB mounted between a frame and a cover
- Weight: 230 g (incl. cover and frame)

Environmental Specifications

- Temperature range (operation): -50..+85°C Tcase (ESMexpress® cover/frame) (qualified components)
- Temperature range (storage): -50..+85°C
- Relative humidity (operation): max. 95% non-condensing
- Relative humidity (storage): max. 95% non-condensing
- Altitude: -300 m to +3000 m
- Shock: 15 g, 11 ms (EN 60068-2-27)
- Bump: 10 g, 16 ms (EN 60068-2-29)
- Vibration (sinusoidal): 1 g, 10 Hz – 150 Hz (EN 60068-2-6)
- Conformal coating on request

MTBF

- 475 088 h @ 40°C according to IEC/TR 62380 (RDF 2000)

Safety

- PCB manufactured with a flammability rating of 94V-0 by UL recognized manufacturers

EMC

- EMC behavior depends on the system and housing surrounding the ESMexpress® module.
- MEN has performed general, successful EMC tests for ESMexpress® using the XC1 evaluation carrier according to:
  - EN 55022 (radio disturbance)
  - IEC 61000-4-2 (ESD)
  - IEC 61000-4-3 (electromagnetic field immunity)
  - IEC 61000-4-4 (burst)
  - IEC 61000-4-5 (surge)
  - IEC 61000-4-6 (conducted disturbances)

BIOS

- U-Boot Universal Boot Loader

Software Support

- VxWorks®
- Linux (on request)
- For more information on supported operating system versions and drivers see online data sheet.

Configuration Options

CPU

- QorIQ™ P4080 or P4040 or P3041
  - P4080: eight cores, up to 16 GB DDR3 RAM (two controllers), 2 MB L3 cache, 30 W max. (processor)
  - P4040: four cores, up to 16 GB DDR3 RAM (two controllers), 2 MB L3 cache, 24 W max. (processor)
  - P3041: four cores, up to 8 GB DDR3 RAM (one controller), 1 MB L3 cache, 18.2 W max. (processor)
- All processors available with 1.2 GHz, 1.33 GHz or 1.5 GHz

Memory

- System RAM
  - One or two memory banks, depending on processor type
  - 2 GB, 4 GB, 8 GB
  - 16 GB (only possible with two banks, P4080 or P4040)
  - Currently only 2 GB are supported by U-Boot and BSP
- Boot/program Flash
  - 64 MB, 128 MB or 256 MB
- FRAM
  - 0 KB or 128 KB

Software Support

- Linux; processors are supported, U-Boot support already implemented

Please note that some of these options may only be available for large volumes. Please ask our sales staff for more information.

For available standard configurations see online data sheet.

Product Safety

Electrostatic Discharge (ESD)

Computer boards and components contain electrostatic sensitive devices. Electrostatic discharge (ESD) can damage components. To protect the board and other components against damage from static electricity, you should follow some precautions whenever you work on your computer.

- Power down and unplug your computer system when working on the inside.
- Hold components by the edges and try not to touch the IC chips, leads, or circuitry.
- Use a grounded wrist strap before handling computer components.
- Place components on a grounded antistatic pad or on the bag that came with the component whenever the components are separated from the system.
- Store the board only in its original ESD-protected packaging. Retain the original packaging in case you need to return the board to MEN for repair.

About this Document

This user manual is intended only for system developers and integrators, it is not intended for end users.

It describes the hardware functions of the board, connection of peripheral devices and integration into a system. It also provides additional information for special applications and configurations of the board.

The manual does not include detailed information on individual components (data sheets etc.). A list of literature is given in the appendix.

History

Issue	Comments	Date
E1	First issue	2011-12-23
E2	General update, minor errors corrected; improved and corrected watchdog description; corrected U-Boot image description	2013-02-04
E3	Removed all ANSI-VITA 59 references.	2014-02-24

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This sign marks important notes or warnings concerning the use of voltages which can lead to serious damage to your health and also cause damage or destruction of the component.

This sign marks important notes or warnings concerning proper functionality of the product described in this document. You should read them in any case.

italics — Folder, file and function names are printed in *italics*.

bold — **Bold** type is used for emphasis.

`monospace` — A `monospaced` font type is used for hexadecimal numbers, listings, C function descriptions or wherever appropriate. Hexadecimal numbers are preceded by "0x".

comment — Comments embedded into coding examples are shown in green color.

hyperlink — Hyperlinks are printed in blue color.

The globe will show you where hyperlinks lead directly to the Internet, so you can look for the latest information online.

IRQ#
/IRQ — Signal names followed by "#" or preceded by a slash ("/") indicate that this signal is either active low or that it becomes active at a falling edge.

in/out — Signal directions in signal mnemonics tables generally refer to the corresponding board or component, "in" meaning "to the board or component", "out" meaning "coming from it".

Vertical lines on the outer margin signal technical changes to the previous issue of the document.

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The WEEE directive does not apply to fixed industrial plants and tools. The compliance is the responsibility of the company which puts the product on the market, as defined in the directive; components and sub-assemblies are not subject to product compliance.

In other words: Since MEN does not deliver ready-made products to end users, the WEEE directive is not applicable for MEN. Users are nevertheless recommended to properly recycle all electronic boards which have passed their life cycle.

Nevertheless, MEN is registered as a manufacturer in Germany. The registration number can be provided on request.

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Germany
MEN Mikro Elektronik GmbH
Neuwieder Straße 3-7
90411 Nuremberg
Phone +49-911-99 33 5-0
Fax +49-911-99 33 5-901
E-mail info@men.de
www.men.de

France
MEN Mikro Elektronik SAS
18, rue René Cassin
ZA de la Châtelaine
74240 Gaillard
Phone +33 (0) 450-955-312
Fax +33 (0) 450-955-211
E-mail info@men-france.fr
www.men-france.fr

USA
MEN Micro Inc.
860 Penllyn Blue Bell Pike
Blue Bell, PA 19422
Phone (215) 542-9575
Fax (215) 542-9577
E-mail sales@menmicro.com
www.menmicro.com

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1 Getting Started

This chapter gives an overview of the board and some hints for first installation in a system.

1.1 Map of the Board

The following board map shows the board assembly from its cover side (top) and connector side (bottom). The cover includes holes for mounting the ESMexpress module onto a COM Express carrier.

Figure 1. *Map of the board – cover side*

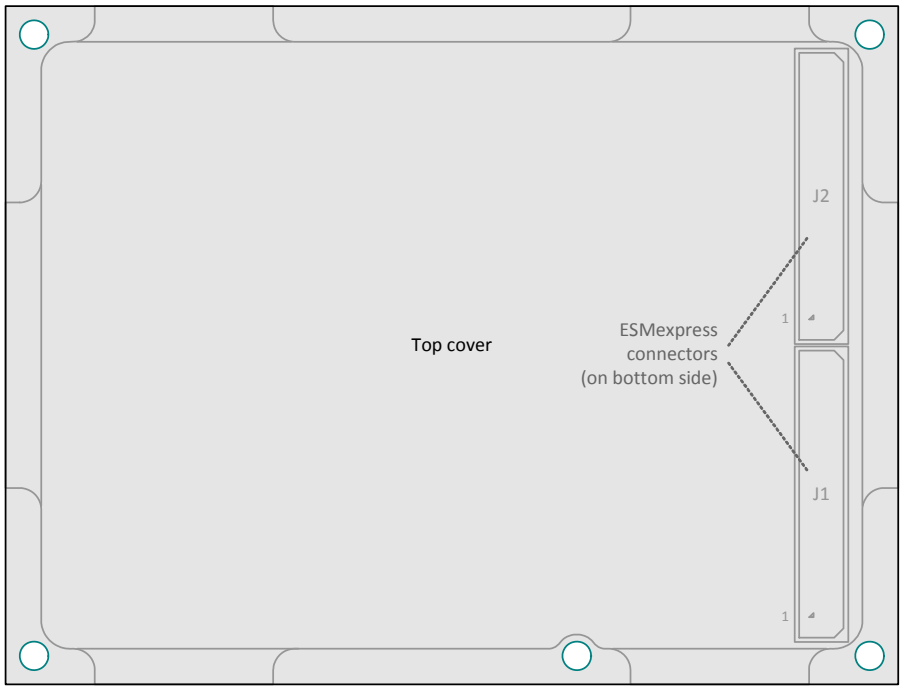
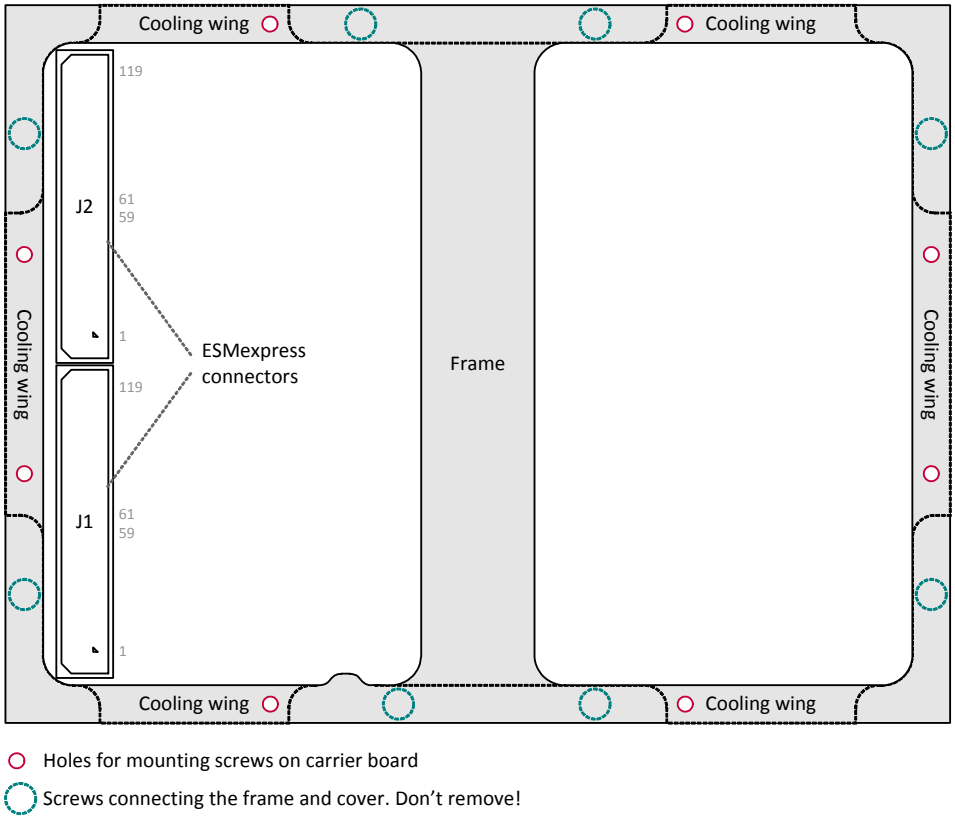


Figure 2. *Map of the board – connector side*



1.2 First Operation

You can use the following check list when installing the board for the first time and with minimum configuration using a Windows host PC.

The U-Boot firmware is preinstalled on the XM51 and is preconfigured for the board.

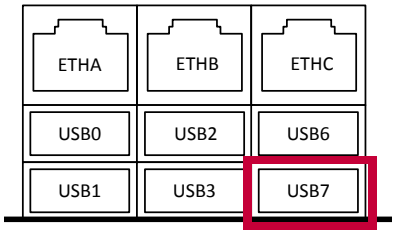
☑ Power-down the system.

☑ Install the XM51 on your ESMexpress carrier board, making sure that the ESMexpress connectors are properly aligned.

To provide a better example, we assume that you are using MEN's standard evaluation carrier, XC1, which provides the necessary connections for a Windows host PC. You can find more information on the XC1 in the XC1 User Manual, which is available for download on MEN's website.

☑ Install a USB-to-UART driver on your host PC.
You can use a driver provided by MEN (article number 13T005-70, third-party) or go to the FTDI web site (www.ftdichip.com/FTDrivers.htm) and download a driver there.

☑ Connect a Windows PC to USB port 7 of XC1 (UART-to-USB COM interface). To do this, you need a suitable USB cable (type A to A, included with XC1).



☑ Power-up the system.

☑ Start up a terminal program on your Windows PC, e.g., HyperTerm, and open a terminal connection.

☑ Set your terminal connection to the following protocol:

- 115 200 baud data transmission rate
- 8 data bits
- 1 stop bit
- No parity

☑ U-Boot will load and then display a command line. The terminal displays a message similar to the following:

```
U-Boot 2010.12 (Nov 17 2011 - 15:24:17) MEN XM51 0.0.0 alpha (64MB fallback)

CPU0:  P4080, Version: 2.0, (0x82000020)
Core:  E500MC, Version: 2.0, (0x80230020)
Clock Configuration:
       CPU0:1200 MHz, CPU1:1200 MHz, CPU2:1200 MHz, CPU3:1200 MHz,
       CPU4:1200 MHz, CPU5:1200 MHz, CPU6:1200 MHz, CPU7:1200 MHz,
       CCB:600  MHz,
       DDR:600  MHz (1200 MT/s data rate) (Asynchronous), LBC:37.500 MHz
       FMAN1: 450 MHz
       FMAN2: 450 MHz
       PME:   450 MHz
L1:    D-cache 32 kB enabled
       I-cache 32 kB enabled
Board: MEN XM51
Reset Configuration Word (RCW):
       00000000: 4c580000 00000000 18185218 0000cccc
       00000010: 389f4440 3c3c2000 fe800000 e1000000
       00000020: 00000000 00000000 00000000 c0ddd0f4
       00000030: a0000000 00000000 00000000 00000000
I2C:   Reset PCIe Bridge... ready
DRAM:  Initializing....using SPD
       (memory mapped)
       Detected UDIMM
       Detected UDIMM
       Detected 4096 MB of memory
       This U-Boot only supports < 4G of DDR
       You could rebuild it with CONFIG_PHYS_64BIT
DDR: 2 GiB (DDR3, 64-bit, CL=8, ECC on)
       DDR Controller Interleaving Mode: cache line
Testing 0x00000000 - 0x7fffffff

...Further test output...

Boot:  os=please_set_to_vxworks_or_linux (e.g. setenv os linux;saveenv) bootmethod=tftp
Auto-update from TFTP: failed, env. variable 'updatefile' not found
Hit any key to stop autoboot:  0
XM51=>
```

Note: Don't power off the XM51 now, otherwise the UART-to-USB interface on the host PC will be disconnected.

☑ Now you can make configurations for your operating system in the U-Boot boot loader. See the detailed description in Chapter 3 U-Boot Boot Loader on page 39.

1.3 Installing Operating System Software

The board supports VxWorks. A Linux BSP is available on request. U-Boot is designed to include Linux support.

By default, no operating system is installed on the board. Please refer to the respective documentation on how to configure your operating system image!

The U-Boot Chapter of this manual describes the first steps of how to get your operating system running, see Chapter 3.2 Getting Started: Setting Up Your Operating System on page 40.

You can find any software available in the XM51 pages on MEN's website.

2 Functional Description

The following describes the individual functions of the board and their configuration on the board. There is no detailed description of the individual controller chips and the CPU. They can be obtained from the data sheets or data books of the semiconductor manufacturer concerned (Chapter 5.1 Literature and Web Resources on page 61).

Please note that the board BSPs for the different operating systems may not support all the functions of the XM51. For more information on hardware support please see the respective BSP data sheet on MEN's website.

2.1 Power Supply

The XM51 board is supplied with +12 V (9 to 16 V) only via ESMexpress connectors J1/J2. All other required voltages are generated on the board.

2.2 Board Supervision

2.2.1 Temperature and Voltage

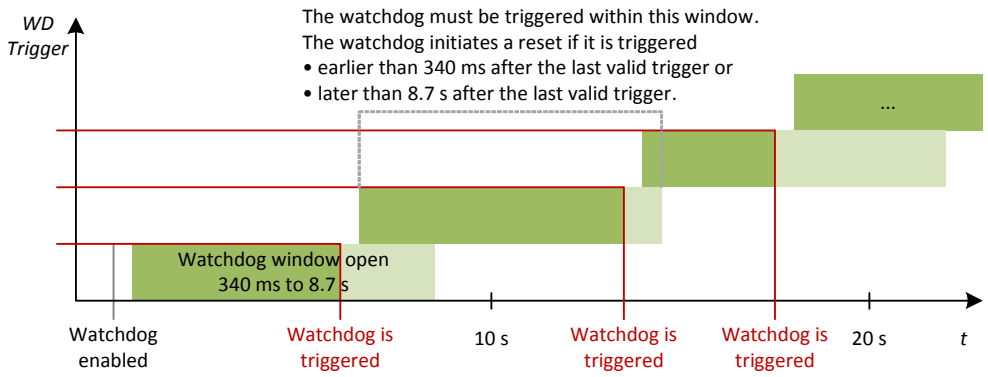
The board features a temperature sensor and voltage monitor.

A voltage monitor supervises all used voltages and holds the CPU in reset condition until all supply voltages are within their nominal values.

2.2.2 Watchdog

The board features a **window watchdog** that must be triggered within a window open period of 340 ms and 8.7 s. After configuration the CPU serves the watchdog. Other than an ordinary timeout watchdog, a window watchdog must be triggered within a certain time window rather than just within a certain maximum time. If the program execution hangs within a loop that includes the function triggering the watchdog, a non-window watchdog might be triggered correctly although there was an error and thus the erroneous situation might stay undetected. Using a window watchdog significantly increases the operational safety.

Figure 3. *Window watchdog triggering*



The watchdog can be enabled or disabled and can be triggered by a software application. This function is normally supported by the board support package (see BSP documentation).

2.3 Real-Time Clock

The board includes an RA8581 real-time clock. For data retention during power off the RTC must be supplied with 3 V via J1 pin *Vbatt* (J1-55) using an external GoldCap or battery device mounted on the carrier board.

2.4 Processor Core

The board is equipped with a multi-core Freescale QorIQ P4080, P4040 or P3041 processor up to 1.5 GHz, which includes four or eight 32-bit Power Architecture e500mc cores, high-performance datapath acceleration logic, and network and peripheral bus interfaces.

2.4.1 General

The QorIQ processor family can be used for combined control, datapath, and application layer processing. Its high level of integration offers significant performance benefits compared to multiple discrete devices, while also greatly simplifying board design. The processor is well-suited for applications that are highly compute-intensive, mission-critical, or both.

The P4080 and P4040 have two independent 64-bit DDR2/3 memory controllers with ECC. All types provide advanced processing, including Datapath Acceleration Architecture for functions like packet parsing, queue management, congestion management or encryption. They also integrate high-speed serial interfaces, with Gigabit Ethernet, PCI Express 2.x and SATA Revision 2.x support. The selection of three different QorIQ-family processor types usable on the XM51 allows tailoring of the computer-on-module for different application requirements.

Table 1. *Processor core options on XM51*

Processor Type	Core Frequency	Cores	DDR3 RAM	L3 Cache	Power Consumption[1]
P4080	1.2 GHz, 1.33 GHz or 1.5 GHz	8	2 controllers, up to 16 GB	2 MB	30 W max.
P4040		4	2 controllers, up to 16 GB	2 MB	24 W max.
P3041		4	1 controller, up to 8 GB	1 MB	18.2 W max.

[1] Only for processor. For a maximum power consumption of the entire COM board, add 2 W each.

2.4.2 Thermal Considerations

The XM51 generates an absolute maximum of 32 W of power dissipation with a P4080 processor operated at 1.5 GHz and supports extended operating temperatures in all configurations.

The ESMexpress module is enclosed inside a cover and frame and therefore provides a flexible thermal interface that can be used as needed to fulfill the thermal needs of the application. Typically you should use it for conduction cooling or convection cooling. It depends on the system configuration and airflow if an additional heat sink is needed or not. In any case you should check your thermal conditions and implement appropriate cooling.

See also Chapter 2.10.2 Thermal Concept on page 27.

Please note that if you do not use the cover and frame supplied by MEN and/or no heat sink, warranty on functionality and reliability of the XM51 may cease. If you have any questions or problems regarding thermal behavior, please contact MEN.

2.5 Memory and Mass Storage

2.5.1 DRAM System Memory

The board provides up to 16 GB onboard, soldered DDR3 SDRAM with ECC (error-correcting code) on two banks. The memory bus is 72 bits wide including ECC and operates at up to 667 MHz (physical), depending on processor configuration.

ECC memory provides greater data accuracy and system uptime by protecting against soft errors in computer memory.

The P4080 and P4040 have two independent memory controllers. The two RAM banks can be assigned to processor cores to avoid access conflicts and assure deterministic behavior. The P3041 has only one controller (and memory bank).

Note: Currently only 2 GB are supported by U-Boot and by the VxWorks BSP.

2.5.2 FRAM

The board has up to 128 KB non-volatile FRAM memory connected to the local bus of the CPU.

The FRAM does not need a back-up voltage for data retention.

2.5.3 NOR Flash

The board includes up to 256 MB soldered NOR Flash memory controlled by the CPU. The data bus is 16 bits wide.

Flash memory contains the U-Boot/operating system bootstrapper and U-Boot environment variables. It can also contain the operating system and application software. See Chapter 3 U-Boot Boot Loader on page 39.

2.5.4 Serial ATA (SATA)

The XM51 provides two serial ATA channels through a PCIe-to-SATA converter that is connected to the QorIQ processor via a dedicated PCIe x1 link. The SATA channels are led to the ESMexpress connector.

The interfaces are compliant with SATA Revision 2.x and support transfer rates of 3.0 Gbits/s.

You can find the pinout for the SATA signals in Table 3, Pin assignment of ESMexpress connector J1, pins 61..120 on page 30.

2.6 USB Interfaces

The XM51 provides four USB 2.0 host ports and one USB client port at the ESMexpress connector.

The four host ports are controlled via a USB hub connected to the QorIQ processor via PCI Express, while the client port is driven by a UART-to-USB converter. All ports are implemented with EHCI/OHCI and support high-speed, fullspeed and low-speed operation.

The UART-to-USB interface supports data rates up to 230.4 kbits/s. It has no handshake lines. In connection with USB-to-UART driver software it can be used as a COM interface and is supported by U-Boot as a console device.

You can find the pinout for the USB signals in Table 3, Pin assignment of ESMexpress connector J1, pins 61..120 on page 30 and Table 4, Pin assignment of ESMexpress connector J1, pins 1..60 on page 31.

2.7 Ethernet Interfaces

The XM51 has two Ethernet interfaces controlled by the CPU. All channels support up to 1000 Mbits/s and full-duplex operation.

You can find the pinout for the Ethernet signals in Table 4, Pin assignment of ESMexpress connector J1, pins 1..60 on page 31.

The unique MAC address is set at the factory and should not be changed. Any attempt to change this address may create node or bus contention and thereby render the board inoperable. The MAC addresses on XM51 are:

- ETHA: `0x 00 C0 3A AE 00 00 - 0x 00 C0 3A AE 07 FF`
- ETHB: `0x 00 C0 3A AE 08 00 - 0x 00 C0 3A AE 0F FF`

where "00 C0 3A" is the MEN vendor code. The last six digits are product-specific and depend on the interface and the serial number of the product. The serial number is added to the channel offset, for example for ETHB: "... `08 2A`" for serial number "000042". (See Chapter 5.2 Finding out the Product's Article Number, Revision and Serial Number on page 62.)

2.8 GPIO

The XM51 provides three GPIO pins driven by the board controller for user-defined options or for board status LEDs. The LEDs can be made available on the carrier board.

The GPIO pins are accessible through driver software provided by the board support package.

The two signals defined by the ESMexpress specification as *PWRBTN#* and *WAKE#* are implemented as GPIO pins on the XM51.

Table 2. *GPIO signals to CPU pins assignment*

XM51 Signal	CPU Signal	CPU Package Pin Number
GPIO/LED#	GPIO24	AG17
GPIO25 (WAKE#)	GPIO25	AM13
GPIO26 (PWRBTN#)	GPIO26	AG13

You can find the GPIO pins in Table 4, Pin assignment of ESMexpress connector J1, pins 1..60 on page 31.

2.9 PCI Express Interface

Two PCI Express x1 links are available on the XM51. The links support PCI Express 2.x with a data rate of 500 MB/s in each direction and a bandwidth of 5 Gbits/s per lane.

The interfaces are numbered A0 and A1 and can be accessed on the ESMexpress connector.

You can find the pinout for the PCI Express signals in Table 3, Pin assignment of ESMexpress connector J1, pins 61..120 on page 30 and Table 6, Pin assignment of ESMexpress connector J2, pins 1..60 on page 33.

2.10 ESMexpress

ESMexpress is a Computer-On-Module (COM/SOM) standard that is especially ruggedized and provides a high-performance, low-power architecture for harsh environments.

The ESMexpress concept has been developed for applications that require highly robust electronics to ensure safe and reliable operation even in severe environments, e.g., in railways and avionics, industrial automation and medical engineering or mobile applications in general.

Together with an application-specific carrier board, it forms a semi-custom solution for industrial, harsh, mobile and mission-critical environments.

2.10.1 Mechanical Concept

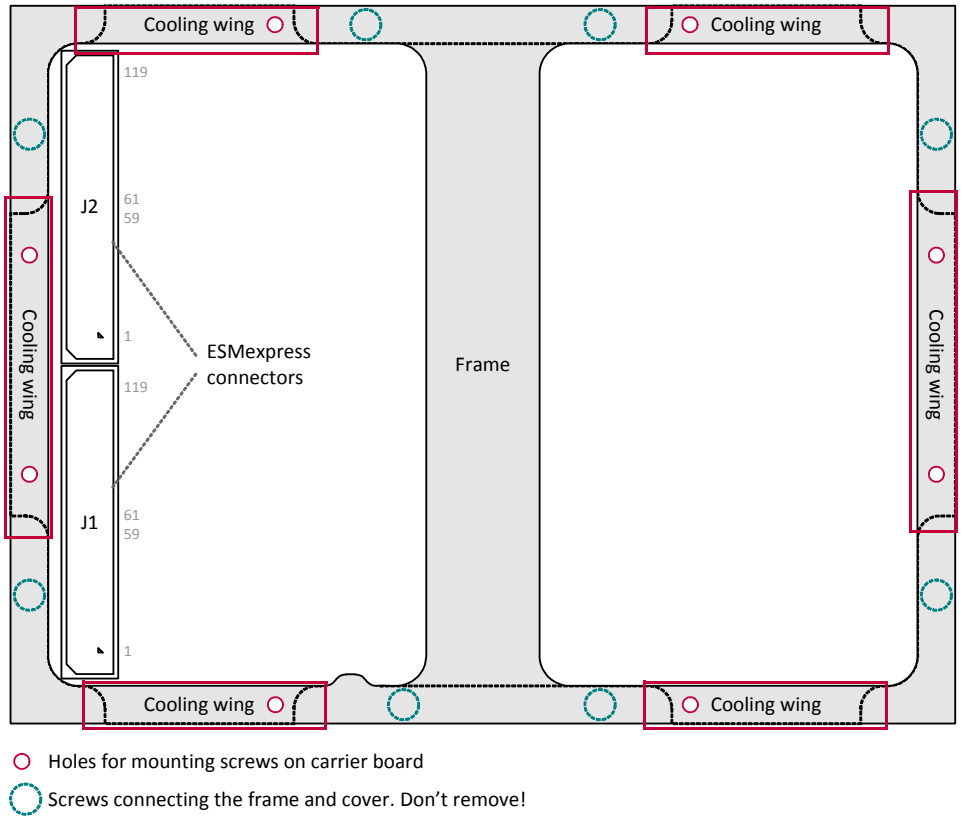
ESMexpress modules are embedded in a frame and a cover, and are firmly screwed to a carrier board. The frame and the cover ensure 100% EMC protection. Only soldered components are used to withstand shock and vibration, and the design is optimized for conformal coating. All ESMexpress modules support a single 95 x 125 mm form factor.

2.10.2 Thermal Concept

ESMexpress modules are equipped with eight cooling wings for conductive cooling. The heat generated on the board is transported to the frame and the cover via the cooling wings. The frame and the cover, however, are only part of the thermal solution for a module. They only provide a common interface between the ESMexpress module and implementation-specific thermal solutions.

The module can e.g. be cooled via conductive cooling, where the heat is transported to a housing or a heat sink built on top of the cover. Where operating temperatures are moderate, the module may even do without the frame and cover, with a suitable low-power processor and airflow.

Figure 4. *ESMexpress thermal concept: cooling wings between frame and cover*



Please contact MEN's sales team for further information.

2.10.3 ESMexpress Connectors

The XM51 is connected to the carrier board via two 120-pin connectors.

Connector types:

- 2-row, 120-pin high-speed receptacle, 0.5mm pitch, e.g. Samtec QSH-060-01-L-D-A-K
- Mating connector:
  2-row, 120-pin high-speed plug connector, 0.5mm pitch

Note: In the following pinout tables the ESMexpress connectors are shown as if seen **through** the cover side and PCB, i.e. the pin layout (position of pin 1) will be the same on a carrier board.

Cf. Figure 1, Map of the board – cover side (page 16) and Figure 2, Map of the board – connector side (page 17).

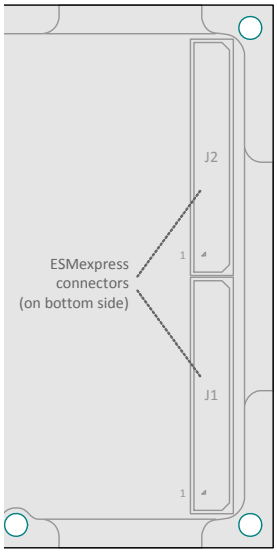
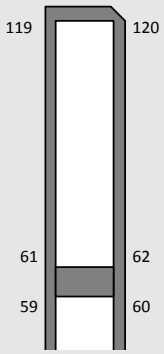
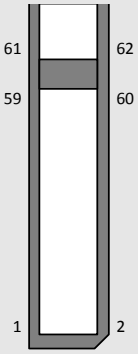


Table 3. *Pin assignment of ESMexpress connector J1, pins 61..120*



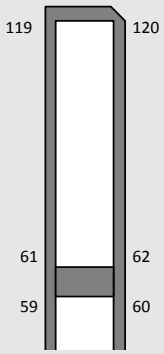
	119	PCIE_A0_TX+		120	PCIE_A0_RX+
	117	PCIE_A0_TX-		118	PCIE_A0_RX-
	115	CLK_REQ_CLK_A0_REF#		116	GND
	113	PCIE_CLK_A0_REF+		114	-
	111	PCIE_CLK_A0_REF-		112	-
	109	-		110	-
	107	-		108	-
	105	-		106	-
	103	-		104	-
	101	-		102	-
	99	-		100	-
	97	GND		98	GND
	95	SATA0_TX+		96	SATA0_RX+
	93	SATA0_TX-		94	SATA0_RX-
	91	GND	GND	92	GND
	89	SATA1_TX+		90	SATA1_RX+
	87	SATA1_TX-		88	SATA1_RX-
	85	GND		86	GND
	83	-		84	-
	81	-		82	-
	79	GND		80	GND
	77	USB0+		78	USB1+
	75	USB0-		76	USB1-
	73	USB_OC_0_1#		74	USB_OC_2_3#
	71	USB2+		72	USB3+
	69	USB2-		70	USB3-
	67	GND		68	GND
	65	-		66	-
	63	-		64	-
	61	-		62	-

Table 4. *Pin assignment of ESMexpress connector J1, pins 1..60*



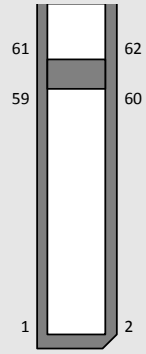
	59	-		60	USB7+ / UART TX
	57	-		58	USB7- / UART RX
	55	Vbatt		56	-
	53	PWR_OK		54	PS_ON#
	51	I2C_DATA		52	RESET_IN#
	49	I2C_CLK		50	RESET_OUT#
	47	-		48	GPIO25 (WAKE#)
	45	GPIO/LED#		46	GPIO26 (PWRBTN#)
	43	-		44	-
	41	-		42	-
	39	-		40	-
	37	-		38	-
	35	-		36	-
	33	-		34	-
	31	-		32	-
	29	-	+12V	30	-
	27	-		28	-
	25	-		26	GND
	23	ETH_B_LED_LINK#		24	ETH_B_LED_ACT#
	21	ETH_B0+		22	ETH_B1+
	19	ETH_B0-		20	ETH_B1-
	17	ETH_B2+		18	ETH_B3+
	15	ETH_B2-		16	ETH_B3-
	13	ETH_B_REF		14	GND
	11	ETH_A_LED_LINK#		12	ETH_A_LED_ACT#
	9	ETH_A0+		10	ETH_A1+
	7	ETH_A0-		8	ETH_A1-
	5	ETH_A2+		6	ETH_A3+
	3	ETH_A2-		4	ETH_A3-
	1	ETH_A_REF		2	GND

Table 5. *Pin assignment of ESMexpress connector J2, pins 61..120*



	119	-		120	-
	117	-		118	-
	115	GND		116	GND
	113	-		114	-
	111	-		112	-
	109	GND		110	GND
	107	-		108	-
	105	-		106	-
	103	GND		104	GND
	101	-		102	-
	99	-		100	-
	97	GND		98	GND
	95	-		96	-
	93	-		94	-
	91	GND	GND	92	GND
	89	-		90	-
	87	-		88	-
	85	GND		86	GND
	83	-		84	-
	81	-		82	-
	79	GND		80	GND
	77	-		78	-
	75	-		76	-
	73	GND		74	GND
	71	-		72	-
	69	-		70	-
	67	GND		68	GND
	65	-		66	-
	63	-		64	-
	61	-		62	-

Table 6. *Pin assignment of ESMexpress connector J2, pins 1..60*



	59	-		60	-
	57	-		58	-
	55	-		56	-
	53	GND		54	GND
	51	-		52	-
	49	-		50	-
	47	GND		48	GND
	45	-		46	-
	43	-		44	-
	41	GND		42	GND
	39	-		40	-
	37	-		38	-
	35	GND		36	GND
	33	-		34	-
	31	-	GND	32	-
	29	GND		30	GND
	27	-		28	-
	25	-		26	-
	23	GND		24	GND
	21	PCIE_CLK_A1_REF+		22	-
	19	PCIE_CLK_A1_REF-		20	-
	17	CLK_REQ_CLK_A1_REF#		18	GND
	15	-		16	-
	13	-		14	-
	11	GND		12	GND
	9	-		10	-
	7	-		8	-
	5	GND		6	GND
	3	PCIE_A1_TX+		4	PCIE_A1_RX+
	1	PCIE_A1_TX-		2	PCIE_A1_RX-

Table 7. *Signal mnemonics of 120-pin ESMexpress connectors*

	Signal	Direction	Function
Power	GND	-	Ground
	Vbatt	in	3V battery voltage
Power Management	PS_ON#	out	Enable signal for external power supply
	PWR_OK	in	Power OK signal from external power supply
	RESET_IN#	in	Reset signal from carrier board
	RESET_OUT#	out	Reset signal from CPU board
PCI Express	CLK_REQ_CLK_A[0:1]_REF#	in	100 MHz Clock request signals
	PCIE_A[0:1]_RX+, PCIE_A[0:1]_RX-	in	Differential PCIe receive lines, x1 links A0 and A1
	PCIE_A[0:1]_TX+, PCIE_A[0:1]_TX-	out	Differential PCIe transmit lines, x1 links A0 and A1
	PCIE_CLK_A[0:1]_REF+, PCIE_CLK_A[0:1]_REF-	out	Reference clocks A0/A1 100 MHz
SATA	SATA0_RX+, SATA0_RX-	in	Differential SATA receive lines, port 0
	SATA0_TX+, SATA0_TX-	out	Differential SATA transmit lines, port 0
	SATA1_RX+, SATA1_RX-	in	Differential SATA receive lines, port 1
	SATA1_TX+, SATA1_TX-	out	Differential SATA transmit lines, port 1
USB	USB0+, USB0-	in/out	Differential USB lines, port 0
	USB1+, USB1-	in/out	Differential USB lines, port 1
	USB2+, USB2-	in/out	Differential USB lines, port 2
	USB3+, USB3-	in/out	Differential USB lines, port 3
	USB7+, USB7-	in/out	Differential UART-to-USB lines (USB port 7) (USB7+ corresponds to UART TX, USB7- corresponds to UART RX)
	USB_OC_0_1#	in	USB overcurrent, ports 0 and 1
	USB_OC_2_3#	in	USB overcurrent, ports 2 and 3

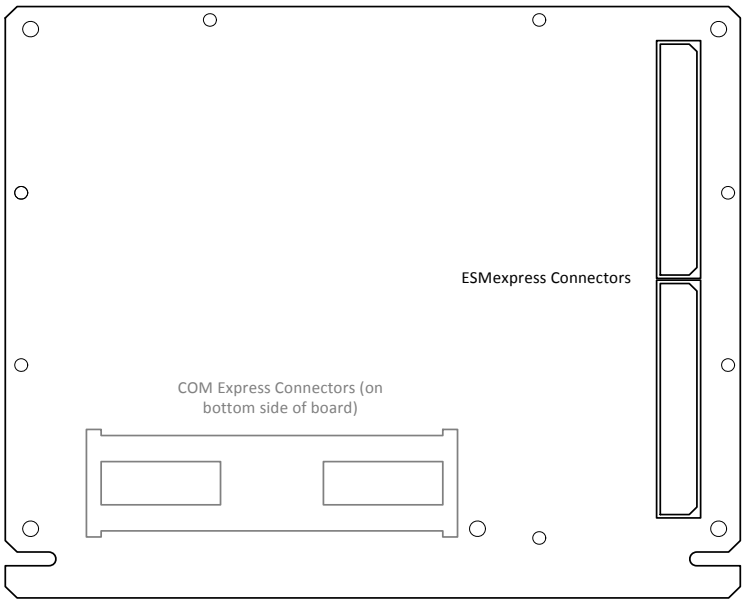
	Signal	Direction	Function
Ethernet	ETH_A_LED_ACT#	out	Signal for activity status LED, port A
	ETH_A_LED_LINK#	out	Signal for link status LED, port A
	ETH_A0+, ETH_A0-	in/out	Media Dependent Interface [0] data, differential pair, port A
	ETH_A1+, ETH_A1-	in/out	Media Dependent Interface [1] data, differential pair, port A
	ETH_A2+, ETH_A2-	in/out	Media Dependent Interface [2] data, differential pair, port A
	ETH_A3+, ETH_A3-	in/out	Media Dependent Interface [3] data, differential pair, port A
	ETH_A_REF	out	Port A reference voltage
	ETH_B_LED_ACT#	out	Signal for activity status LED, port B
	ETH_B_LED_LINK#	out	Signal for link status LED, port B
	ETH_B0+, ETH_B0-	in/out	Media Dependent Interface [0] data, differential pair, port B
	ETH_B1+, ETH_B1-	in/out	Media Dependent Interface [1] data, differential pair, port B
	ETH_B2+, ETH_B2-	in/out	Media Dependent Interface [2] data, differential pair, port B
	ETH_B3+, ETH_B3-	in/out	Media Dependent Interface [3] data, differential pair, port B
	ETH_B_REF	out	Port B reference voltage
Other	I2C_CLK	in/out	I2C clock
	I2C_DATA	in/out	I2C data
	GPIO/LED#	in/out	User-defined GPIO/LED (GPIO24 of CPU, CPU pin AG17)
	GPIO25 (WAKE#)	in/out	Defined by ESMexpress specification as PCI Express Wake Event, but on XM51 implemented and usable as a GPIO line (GPIO25 of CPU, CPU package pin number AM13)
	GPIO26 (PWRBTN#)	in/out	Defined by ESMexpress specification as Power Button, but on XM51 implemented and usable as a GPIO line (GPIO26 of CPU, CPU package pin number AG13)

2.10.4 Using an ESMexpress Module on a COM Express Carrier Board

The AE12 adapter card offers the possibility to evaluate an ESMexpress module on a COM Express carrier board. It complies with the COM Express Type 2 basic form factor.

On its top side the AE12 has ESMexpress connectors for connecting the ESMexpress module. On the bottom side the AE12 card is equipped with standard COM Express connectors for plugging it onto the COM Express carrier.

Figure 5. *AE12 COM Express adapter board – Map of the board*

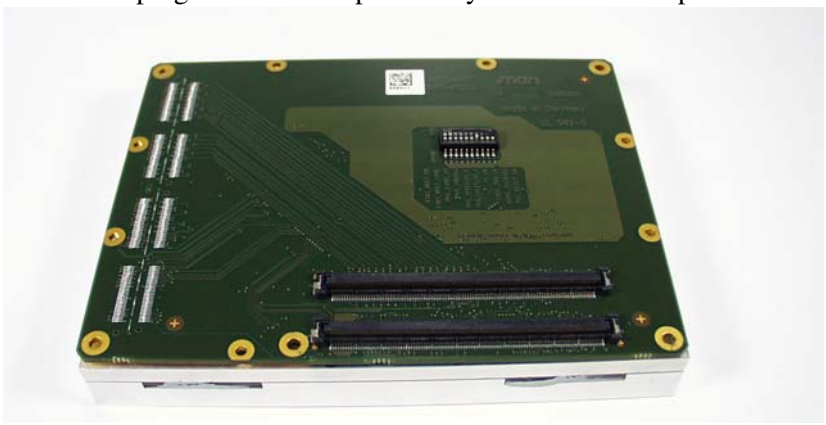


The pin assignment of the COM Express connectors is compliant to the COM Express standard.

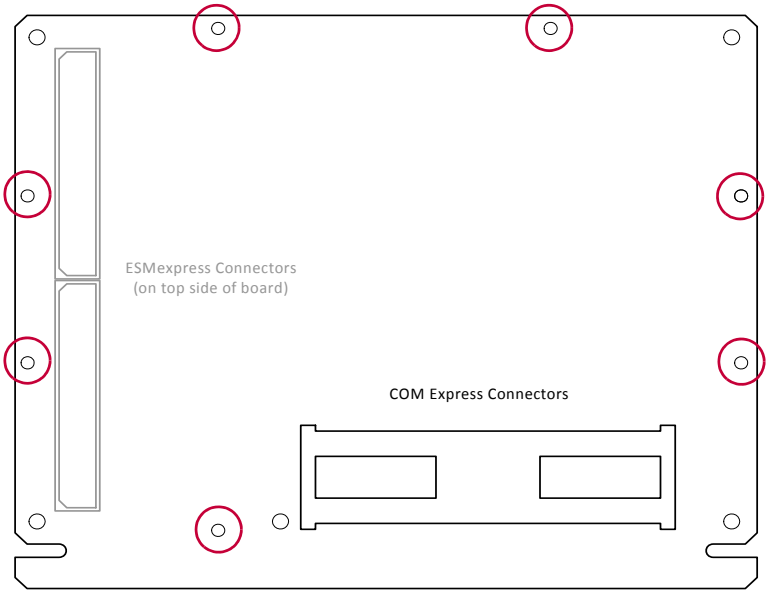
The pin assignment of the ESMexpress connectors is compliant to the ESMexpress standard.

Installing the ESMexpress Module on a COM Express Carrier

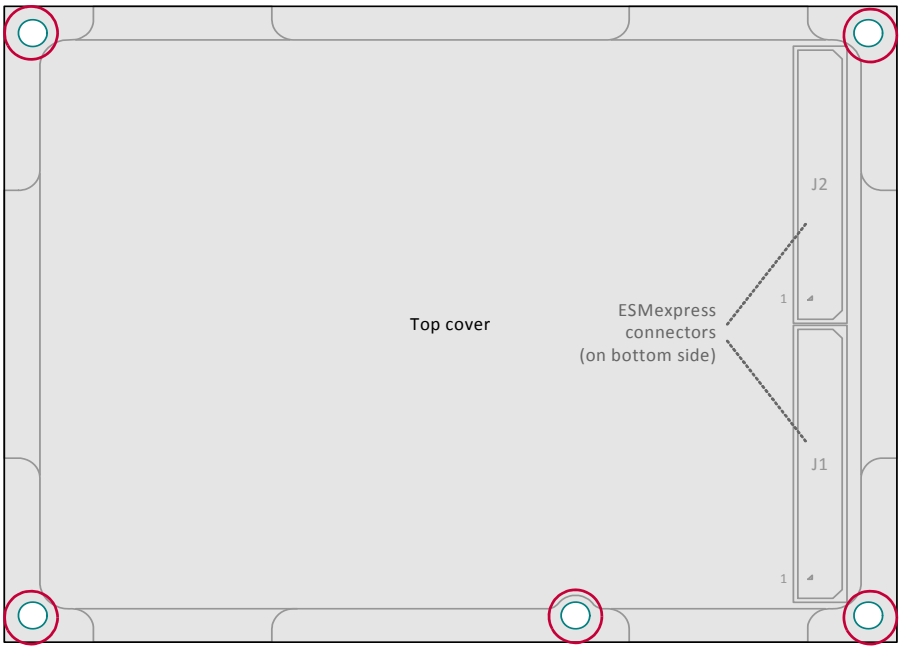
☑ Align the ESMexpress connectors and the mounting holes of the adapter and the module and plug the AE12 adapter firmly onto the ESMexpress module.



☑ Install the ESMexpress module on the adapter using the following mounting holes and the seven M2x4 cross-recess pan-head screws included in the delivery of the adapter:



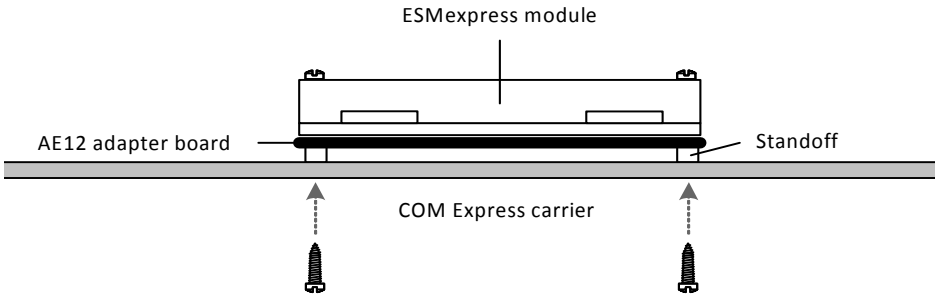
☑ Turn the module around and insert five 2.5x18 cross-recess countersink-head screws (also included in the delivery) into the five COM Express mounting holes on the top of the ESMexpress module.



☑ Install the five 2.5x5 standoffs on the bottom of the adapter.

☑ Plug the ESMexpress module/AE12 assembly onto the COM Express carrier board.

☑ Screw the adapter onto the COM Express carrier board using five M2.5x4 screws.



3 U-Boot Boot Loader

3.1 General

U-Boot is the CPU board firmware that is invoked when the system is powered on.

The basic tasks of U-Boot are:

- Initialize the CPU and its peripherals.
- PCI configuration.
- Provide debug/diagnostic features on the U-Boot command line.
- Boot operating system via Flash, TFTP or similar methods.

U-Boot for XM51 consists of the standard U-Boot code and a board-specific patch. The current patch file and the complete binaries (prebuilt main U-Boot image) are available for download on MEN's website.

Note: U-Boot for XM51 was already designed to support both VxWorks (BSP available) and Linux (BSP on request). Therefore, Linux was also considered in the following description of U-Boot.

The following description only includes board-specific features. For a general description and in-depth details on U-Boot, please refer to the DENX U-Boot and Linux Guide (DULG) available under www.denx.de/wiki/DULG/WebHome. (For a PDF version refer to Chapter 2.3 Availability.)

For advanced developing and programming, you can also use the following resources:

- U-Boot source code on the DENX website (also includes README files): http://git.denx.de (GIT repositories) and ftp://ftp.denx.de/pub/u-boot (TAR archives)
- U-Boot mailing list: http://lists.denx.de/mailman/listinfo/u-boot

3.2 Getting Started: Setting Up Your Operating System

This chapter describes a recommended procedure of how to get your operating system running for the first time, using MEN's XC1 evaluation carrier board.

When U-Boot starts up for the first time, it does not know yet which operating system (OS) to load and normally stops the boot procedure by its prompt. (If you don't see the U-Boot prompt, reset the board again and press any key during start-up.) You need to make the necessary settings first and then load a boot image, e.g., via network.

The following gives an example of how to integrate and boot the example images for Linux or VxWorks provided by the MEN BSPs. In the example, the images are loaded from a host computer via TFTP.

Note: This procedure uses the U-Boot standard commands to make the individual steps clearer. For your actual application, you can use additional environment variables that the XM51 U-Boot provides for booting, and which short-cut the individual steps shown below. See Chapter 3.4.1 Booting an Operating System on page 45.

☑ Connect the host computer where your boot image is located to the XM51's ETHA Ethernet port.

3.2.1 Setting Up the Boot File

☑ Create a boot file for your operating system on your host computer.

3.2.2 Setting Up the Boot and TFTP Parameters

☑ Set the network parameters through the U-Boot environment variables for the network connection:

```
XM51=> editenv ipaddr
edit: 192.1.1.120     Edit IP address and press <Enter>
XM51=> editenv serverip
edit: 192.1.1.22      Edit TFTP server IP address and press <Enter>
XM51=> editenv gatewayip
edit: 192.1.1.22      Edit IP address of the gateway and press <Enter>
XM51=> editenv netmask
edit: 255.255.255.0   Edit the subnet mask and press <Enter>
```

☑ Set up the boot file through environment variable *bootfile*, e.g.:

```
Linux:
XM51=> setenv bootfile /tftpboot/pMulti_XM51
VxWorks:
XM51=> setenv bootfile /tftpboot/vxW_XM51.st
```

☑ Set the boot arguments through environment variable *bootargs*, e.g.:

```
Linux:
XM51=> setenv bootargs root=/dev/ram rw
VxWorks:
XM51=> setenv bootargs dtsec(0,0)xm51:${bootfile} e=$
{ipaddr} h=${serverip} g=${gatewayip} u=username pw=password tn= s=
                                    'u' is the FTP user name
                                              'pw' is the FTP password
```

☑ Set up the autostart script through environment variable *bootcmd*:

Linux:
```
XM51=> setenv bootcmd 'tftpboot && bootm'
```
VxWorks:
```
XM51=> setenv bootcmd 'tftpboot && cpenv && bootvx'
```

3.2.3 Starting Up the Operating System

☑ Save the changed environment variables.

```
XM51=> saveenv
```

☑ Reset the board.

```
XM51=> reset
```

☑ U-Boot restarts the board and loads the configured operating system with the settings made.

3.3 Interacting with U-Boot

U-Boot uses a shell similar to the Linux Hush shell with a command history and autocompletion support.

3.3.1 Setting Up a Console Connection

To interact with U-Boot, you can use the UART-to-USB interface (UART COM1) as a serial console port in RS232 mode. (See Chapter 2.6 USB Interfaces on page 25.)

You can select the active console by means of environment variables *stdin*, *stdout* and *stderr*, see Table 11, U-Boot – Environment variables – Console on page 55. U-Boot command *coninfo* lists all active consoles.

The default setting of the COM ports is 115200 baud, 8 data bits, no parity, and one stop bit. (You can set the baud rate through environment variable *baudrate*, see description on page 55.)

3.3.2 Entering the U-Boot Command Line

During normal boot, you can abort the booting process by pressing any key during start-up.

By default, autoboot waits 3 seconds (measured from its beginning) before it starts the operating system, to give the user a chance to abort booting and enter the command line.

You can modify the autoboot wait time through U-Boot environment variable *bootdelay* (see Table 9, U-Boot – Environment variables – OS boot on page 53).

3.3.3 User Interface Basics

3.3.3.1 Help and Navigation

Use the *help* command to get a list of available commands.

Arrow keys "up" ↑and "down" ↓ let you navigate in the command line history.

The <*TAB*> key autocompletes commands and variables.

You can press <*CTRL*> <*c*> to abort.

3.3.3.2 Configuring Your System

Use environment variables to configure your system. They can be viewed using the *printenv* command. To set or add variables, you can use commands *editenv* and *setenv*. To save the changed parameters use *saveenv*. Using command *defenv* the environment variables can be reset to default values.

Examples: Displaying environment variables

```
XM51=> printenv baudrate
baudrate=115200

XM51=> printenv    Print all variables
baudrate=115200
bootdelay=3
...

XM51=> echo "Server IP: ${serverip}"    Shell variable expansion
Server IP: 192.1.1.22
```

Examples: Editing and saving environment variables

```
XM51=> editenv ipaddr
edit: 192.1.1.023    Edit the variable in the edit line and press <Enter>

XM51=> setenv ipaddr 192.1.1.123    Edit a variable directly

XM51=> setenv ipaddr    Deletes a variable completely

XM51=> defenv    Set all variables to default

You need to save the changes made, otherwise they will be lost after next reset:
XM51=> saveenv
Saving Environment to Flash...
```

For a list of the XM51 environment variables see Chapter 3.7.2 Environment Variables on page 53.

3.3.3.3 Working with Scripts and Applications

You can use scripts or stand-alone applications for more complex tasks. Scripts can be stored in environment variables and executed by the *run* command.

You can enter a sequence of commands using different separators:

- ; separated = all commands are executed
- && separated = next command is executed only if no error occurred
- || separated = next command is executed only if an error occurred

Simple Scripts using the Command Line

You can create a script using the command line, and you can store it in an environment variable:

☑ Create script (i.e. store list of commands in variable) (see also www.denx.de/wiki/view/DULG/CommandLineParsing):

```
XM51=> setenv menu_script 'echo "1=VxWorks"; echo "2=Linux"; echo
"3=Mem test"; askenv _number; if test ${_number} = 1; then run
vxworks; elif test ${_number} = 2; then run linux; else mtest; fi'
```

☑ Save the script in an environment variable (optional):

```
XM51=> saveenv
```

☑ Execute the script:

```
XM51=> run menu_script
```

Scripts using Source Files

For more complex scripts, you can write a text file on your host computer, convert it, load it into the XM51 Flash and run it on the board from the source file. The following shows how an example script is created on a Linux host computer:

☑ Write the script as a TXT file. In the example, we have written a file called *brd_info.txt*:

```
# example U-Boot script (show board info)
#
# convert:
# mkimage -A ppc -O linux -T script -C none -a 0 -e 0 -n "board info
script" -d ./brd_info.txt ./brd_info.scr

echo
echo Version:
echo -------- \\c      # \\c = no new line
version
echo
echo Board:
echo ------ \\c
eeprod
echo
clocks
echo
echo Network:
echo --------
echo Interface: ${ethact}
echo Target: ${ipaddr} (${ethaddr})
echo Server: ${serverip}
echo
echo bdinfo:
echo --------
bdinfo
echo
```

☑ Convert the TXT script to *.scr* format:

```
me@server:/> mkimage -A ppc -O linux -T script -C none -a 0 -e 0 -n
"board info script" -d /examples/brd_info.txt /tftpboot/
brd_info.scr
```

☑ Download the script via network using the U-Boot command line:

```
XM51=> tftpboot 192.1.1.22:/tftpboot/brd_info.scr
```

☑ Execute the script:

```
XM51=> source ${loadaddr}
```

3.4 U-Boot Image and Start-Up

U-Boot only has a **main image** for normal operation. The main image is stored in the onboard boot Flash. U-Boot for XM51 has no fallback image.

After a board reset, the CPU starts executing the main image. This makes for a very fast start-up.

To update U-Boot, you can use "run update_fb".

3.4.1 Booting an Operating System

U-Boot provides the *bootm* and *bootvx* commands to support booting of Linux and VxWorks.

You can completely configure how U-Boot boots the operating system through environment variables. Variables *bootargs* and *bootcmd* include the arguments to be set and commands to be executed at boot-up to start the operating system. (See examples in Chapter 3.2.2 Setting Up the Boot and TFTP Parameters on page 40.)

3.4.1.1 Boot Methods

Note: Please note that booting via SATA is not supported.

Note: Please remember to save the settings you have made in the environment variables using *saveenv*.

OS Boot via Network

U-Boot command *tftpboot* allows loading of the operating system via the board's Ethernet interface using the TFTP protocol. You can find a detailed description of the necessary settings in Chapter 3.2.2 Setting Up the Boot and TFTP Parameters on page 40.

OS Boot via Boot Flash

U-Boot maps Flash memory directly into the CPU memory space to make it possible to load an operating system binary stored in the onboard boot Flash.

☑ Set the boot arguments through environment variable *bootargs*, e.g.:

```
Linux:
XM51=> setenv bootargs root=/dev/ram rw
VxWorks:
XM51=> setenv bootargs dtsec(0,0)xm51:${bootfile} e=$
{ipaddr} h=${serverip} g=${gatewayip} u=username pw=password tn= s=
                                        'u' is the FTP user name
                                                'pw' is the FTP password
```

☑ Set up the autostart script through environment variable *bootcmd*:

```
Linux:
XM51=> setenv bootcmd 'bootm 0xec020000'
VxWorks:
XM51=> setenv bootcmd 'cpenv && bootvx 0xec020000'
```

OS Boot via USB

U-Boot commands *ext2load*, *fatload*, *reiserload* or *usbboot* (raw) allow loading of the operating system via USB mass storage devices connected to the onboard PCI USB controller, i.e. USB ports USB0 to USB3. The command to be used depends on the file system of the USB device. (See also Chapter 3.6.2 USB on page 51.)

Example with *fatload*:

☑ Set the load address to the default DRAM value in environment variable *loadaddr*:

```
XM51=> setenv loadaddr 0x02000000
```

☑ Set up the boot file through environment variable *bootfile*, e.g.:

```
Linux:
XM51=> setenv bootfile /pMulti_XM51
VxWorks:
XM51=> setenv bootfile /vxW_XM51.st
```

☑ Set the boot arguments through environment variable *bootargs*, e.g.:

```
Linux:
XM51=> setenv bootargs root=/dev/ram rw
VxWorks:
XM51=> setenv bootargs dtsec(0,0)xm51:${bootfile} e=$
{ipaddr} h=${serverip} g=${gatewayip} u=username pw=password tn= s=
                                        'u' is the FTP user name
                                                'pw' is the FTP password
```

☑ Set up the autostart script through environment variable *bootcmd* to initialize the USB device and load the boot file into DRAM:

```
Linux:
XM51=> setenv bootcmd 'usb start; fatload usb 0:1 ${loadaddr}
${bootfile}; bootm'                              0:1 = device 0 partition 1
VxWorks:
XM51=> setenv bootcmd 'usb start; fatload usb 0:1 ${loadaddr}
${bootfile}; cpenv && bootvx'                    0:1 = device 0 partition 1
```

3.4.1.2 Configuring Boot using Additional Environment Variables

Due to additional environment variables provided by the XM51 U-Boot, it takes only a few steps to configure booting:

☑ Set the operating system to *linux* or *vxworks* through environment variable *os*:

```
XM51=> setenv os linux
```

☑ Set the boot method to *flash*, *tftp* or *usb* through environment variable *bootmethod*:

```
XM51=> setenv bootmethod tftp
```

☑ Set the boot files:

```
Linux:
XM51=> editenv linux_file
VxWorks:
XM51=> editenv vxworks_file
```

☑ Set the boot arguments (the defaults should work in most cases):

```
Linux:
XM51=> editenv linux_setargs
VxWorks:
XM51=> editenv vxworks_setargs
```

☑ For VxWorks: If you want to boot a VxWorks SMP image (to use all 8 CPU cores) you need to set *mp_holdoff* to *yes*:

```
XM51=> setenv mp_holdoff yes
```

☑ Set environment variable *bootcmd*:

```
XM51=> setenv bootcmd 'run ${os}'
```

☑ If you want to start the boot directly from U-Boot, execute:

```
Linux:
XM51=> run linux
VxWorks:
XM51=> run vxworks
```

3.5 Updating the Boot Flash

You can update U-Boot and other binaries located in the boot Flash via a serial console connection, network or USB device.

The XM51 U-Boot supports hardware protection.

3.5.1 Update via the Serial Console

U-Boot provides the *loady*, *protect*, *erase* and *cp* commands to download a binary update file and program the boot Flash.

The terminal emulation program must be configured to start the upload via the "Ymodem" (for *loady*) or "Kermit" protocol (for *loadb* and *loads*) and send the required file.

3.5.2 Update via Network

You can use U-Boot commands *tftpboot*, *protect*, *erase* and *cp* to download the binary update file from a TFTP server in the network and program the boot Flash.

3.5.3 Update via USB

You can also make a Flash update from a USB device, e.g., a USB Flash drive. Use the U-Boot *ext2load*, *fatload*, *reiserload* or *usbboot* (raw) command.

3.5.4 Performing an Update

To perform an update, e.g., of your operating system image inside the Flash, use the following procedure.

For instructions on how to update the U-Boot code itself, please see Chapter 3.5.5 Updating U-Boot Code on page 50.
For a memory map of the Flash, please see Chapter 3.7.1 Boot Flash Memory Map on page 53.

☑ Download the update file:

```
Via serial console, e.g., with Y protocol:
XM51=> loady
Via network, e.g.:
XM51=> tftpboot 192.1.1.22:/path/file.bin
Via USB storage, e.g.:
XM51=> usb start; fatload usb 0:1 ${loadaddr} /file.bin
                                  0:1 = device 0 partition 1
```

☑ Unprotect the Flash (i.e. unlock Flash sector protection):

```
XM51=> protect off 0xec020000 +${filesize}
                   0xec020000 is the update address
```

☑ Erase the part of the Flash that you want to update:

```
XM51=> erase 0xec020000 +${filesize}
```

☑ Write the file to Flash:

```
XM51=> cp.b ${loadaddr} 0xec020000 ${filesize}
```

☑ Protect the Flash again:

```
XM51=> protect on all
```

If you want to do your updates in a more user-friendly way, you can create a script that includes the above steps:

☑ Create a new update script in an environment variable, e.g.:

```
XM51=> setenv update_os 'setenv bootfile /tftpboot/pMulti_XM51 &&
editenv bootfile && setenv loadaddr 02000000 && tftpboot && itest
${filesize} != 0 && protect off ec020000 efdfffff && erase ec020000
+${filesize} && cp.b ${loadaddr} ec020000 $ {filesize}; protect on
all'
```

☑ Save the script (optional):

```
XM51=> saveenv
```

☑ Start the update:

```
XM51=> run update_os
```

3.5.5 Updating U-Boot Code

Updates of the XM51 U-Boot (only main image) are available for download from MEN's website. U-Boot's integrated Flash update functions allow you to do updates yourself. However, you need to take care and follow the instructions given here. Otherwise, you may make your board inoperable!

In any case, read the following instructions carefully!

Please be aware that you do U-Boot updates at your own risk. After an incorrect update your CPU board may not be able to boot.

Do the following to update U-Boot:

- ☑ Unzip the downloaded file, e.g., *14XM51-00_01_02.zip*, into a temporary directory.
- ☑ Connect a terminal emulation program with the UART-to-USB interface (UART COM1) of your XM51 and set the terminal emulation program to 115200 baud, 8 data bits, 1 stop bit, no parity, no handshaking (if you haven't changed the target baud rate before).
- ☑ Power on your XM51 and press "ENTER" immediately.
- ☑ In your terminal emulation program, you should see the U-Boot prompt.

```
XM51=>
```

- ☑ Enter *run update*:

```
XM51=> run update
```

Note: Please note that the current U-Boot implementation only supports the fallback image. To update U-Boot, please use *run update_fb*.

- ☑ U-Boot asks you by which means you want to do the update. Type in *uart* and <*ENTER*>.

```
Please enter 'tftp,bootp or uart':uart
via UART:
## Ready for binary (ymodem) download to 0x02000000 at 115200 bps...
C(CAN) packets, 3 retries
## Total Size      = 0x00061a1c = 399900 Bytes
....... done
Un-Protected 7 sectors

.... done
Erased 4 sectors
Copy to Flash... done
Protect Flash Bank # 1
................................................................
.........................e
XM51=>
```

- ☑ In your terminal emulation program, start a "YModem" download of the image file, e.g., *u-boot_XM51_1.0.bin*. For example, with Windows Hyperterm, select *Transfer* > *Send File* with protocol "YModem".
- ☑ As the last step after the download, the Flash is programmed. When the update procedure has completed, reset the XM51.

3.6 Accessing Devices

U-Boot provides some useful commands especially for PCI, USB and I2C devices.

For a complete list of available U-Boot commands, see Chapter 3.8 U-Boot Commands on page 56.

3.6.1 PCI

List PCI devices

pci [bus] [long]	List of PCI devices on bus *bus* (long = detailed)

Read (config space)

pci display[.b,.w,.l] b.d.f [addr] [no_of_objects]	Read config space
pci header b.d.f	Show header of PCI device 'bus.device.function'

Write (config space)

pci write[.b,.w,.l] b.d.f addr value	Write to config space
pci modify[.b,.w,.l] b.d.f addr	Modify config space (read, write)
pci next[.b,.w,.l] b.d.f addr	Modify config space (const. addr.)

3.6.2 USB

Before you access USB devices you have to call *usb start*. At compilation time, a specific USB controller must be configured, e.g., the EHCI (high-speed) onboard PCI/USB controller. This means that high-speed and low/full-speed devices cannot be supported at the same time.

List all devices

usb tree	Show USB device tree
usb info [dev]	Show available USB devices

List storage devices

usb storage	Show details of USB storage devices
usb part [dev]	Print partition table of one or all USB storage devices

Read RAW data

usb dev [dev]	Show or set current USB storage device
usb read addr blk# cnt	Read *cnt* blocks starting at block *blk#* to memory address *addr*

Read file system

Use commands *ext2load*, *ext2ls*, *fatinfo*, *fatload*, *fatls*, *reiserload* or *reiserls*, e.g.:

```
XM51=> fatinfo usb 0:1    0:1 = device 0 partition 1
XM51=> fatls usb 0:1      use usb part to find dev/part
XM51=> fatload usb 0:1 ${loadaddr} /path/file
```

3.6.3 I2C

Set bus

i2c dev [dev]	Show or set current I2C bus

List

i2c probe	Show devices on the I2C bus

Read

i2c md chip addr[.0, .1, .2] [no_of_objects]	Read from I2C device
i2c loop chip addr[.0, .1, .2] [no_of_objects]	Loop reading of device

Write

i2c mm chip addr[.0, .1, .2]	Write (modify)
i2c mw chip addr[.0, .1, .2] value [count]	Write (fill)
i2c nm chip addr[.0, .1, .2]	Write (constant addr.)

3.7 U-Boot Configuration and Organization

3.7.1 Boot Flash Memory Map

Table 8. *U-Boot – Boot Flash memory map*

CPU Address Space	Size	Description
0x Ex00 0000..Ex01 FFFF[1]	128 KB	0x Ex00 0000: Reset Configuration Word & Pre-Boot 0x Ex00 3000: SPD data for DDR SDRAM 0x Ex00 4000: P3041 Microcode
0x Ex02 0000..EFDF FFFF[1]	Flash size - 2176 KB	Available to user
0x EFE0 0000..EFE1 FFFF	128 KB	Reserved for MEN production data or redundant U-Boot environment
0x EFE2 0000..EFEF FFFF	896 KB	U-Boot binary
0x EFF0 0000..EFF1 FFFF	128 KB	U-Boot Parameter Section
0x EFF2 0000..EFFF FFFF	896 KB	U-Boot binary (fallback)

[1] The base address differs depending on the Flash size:
64 MB Flash: x = 0xC
128 MB Flash: x = 0x8
256 MB Flash: x = 0x0

3.7.2 Environment Variables

U-Boot uses environment variables to configure the target. The available variables are board-specific for the XM51.

Environment variables are stored in Flash. They can be viewed using the *printenv* command. To set or add variables, you can use commands *editenv* and *setenv*. To save the changed parameters use *saveenv*. See Chapter 3.3.3.2 Configuring Your System on page 42 for command line examples.

Table 9. *U-Boot – Environment variables – OS boot*

Variable	Description	Default	Access
bootargs	Boot arguments when booting an OS image	The boot command will set *bootargs*.	r/w
bootcmd	Command string that is automatically executed after reset	*run ${os}*	r/w
bootdelay	Delay before the default image is automatically booted. Set to -1 to disable autoboot	3	r/w
bootmethod[1]	Method to boot operating system Possible values: *bootp*, *flash*, *tftp*, *usb*	*tftp*	r/w
linux_file[1]	Linux boot file used by default *bootcmd*	*/tftpboot/pMulti_XM51*	r/w
linux_setargs[1]	Used to set *bootargs* Default: *setenv bootargs root=/dev/ram rw console=ttyS0,${baudrate}*		r/w

Variable	Description	Default	Access
linux[1]	Example script for booting Linux Default: *setenv bootfile ${linux_file};setenv loadaddr 02000000;run linux_setargs ${bootmethod};bootm ${loadaddr}*		r/w
os[1]	Operating system to boot (e.g., *vxworks*, *linux*)	*--- do not boot ---*	r/w
vxworks_file[1]	VxWorks boot file used by default *bootcmd*	*/tftpboot/vxW_XM51.st*	r/w
vxworks_setargs[1]	Used to set *bootargs* Default: *setenv bootargs dtsec(0,0)${hostname}:${bootfile} e=${ipaddr} h=${serverip} g=${gatewayip} u=${user} pw=${pwd} tn=${target} s=${script}*		r/w
vxworks[1]	Example script for booting VxWorks Default: *${vxworks_file};setenv loadaddr 02000000;run vxworks_setargs ${bootmethod};cpenv;bootvx ${loadaddr}*		r/w

[1] These MEN-specific variables can be used to provide a user-friendly way to boot the operating system: Once files and arguments are set correctly, the user can boot the operating system using commands *boot*, *run linux* or *run vxworks*.

Table 10. *U-Boot – Environment variables – Network*

Variable	Description	Default	Access
bootfile	Name of the image to load through command *tftpboot*	Empty	r/w
ethact	Controls which network interface is currently active	*FM1@DTSEC1*	r/w
ethaddr *eth1addr*	MAC addresses of first Ethernet interface (FM1@DTSEC1) and second Ethernet interface (FM1@DTSEC2) determined at start-up (see Chapter 2.7 Ethernet Interfaces on page 25). You can pass MAC addresses to the OS using the *cpenv* command.	*00:c0:3a:ae:00:00* *00:c0:3a:ae:08:00*	r
gatewayip	IP address of the gateway (router) to use	*192.1.1.22*	r/w
hostname	Target host name	Empty	r/w
ipaddr	IP address; needed for *tftpboot* command	*192.1.1.120*	r/w
loadaddr	Default load address for commands like *bootp*, *tftpboot*, *loadb* etc.	*0x01000000*	r/w
netmask	Subnet mask	*255.255.255.0*	r/w
pwd	Password	Empty	r/w
serverip	TFTP server IP address; needed for *tftpboot* command	*192.1.1.22*	r/w
user	User name	Empty	r/w

Table 11. *U-Boot – Environment variables – Console*

Variable	Description	Default	Access
baudrate	Baud rate for serial console Possible values: 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200	*115200*	r/w
loads_echo	If set to 1, all characters received during a serial download (using the *loads* command) are echoed back. This might be needed by some terminal emulations (like *cu*), but may just take time on others.	*1*	r/w
stderr	Standard error console Possible values: *serial*	*serial*	r/w
stdin	Standard input console Possible values: *serial*	*serial*	r/w
stdout	Standard output console Possible values: *serial*	*serial*	r/w

Table 12. *U-Boot – Environment variables – Other*

Variable	Description	Default	Access
update[1]	Example U-Boot update script, see Chapter 3.5.4 Performing an Update on page 48 Default: *askenv \"tftp,bootp or uart\";if test \"tftp\" = ${tftp,bootp or uart};then setenv bootfile /tftpboot/u-boot_"CONFIG_MEN_BOARD".bin;editenv bootfile;fi;setenv loadaddr 02000000;run ${tftp,bootp or uart}&&itest ${filesize} != 0&&protect off efe20000 efeffffff&&erase efe20000 +${filesize}&&cp.b ${loadaddr} efe20000 ${filesize};protect on all* **Note: Currently the *update* variable has no function.**		r/w
update_fb[1]	Example U-Boot update script (for fallback image), see Chapter 3.5.4 Performing an Update on page 48 Default: *askenv "tftp,bootp or uart";if test "tftp" = ${tftp,bootp or uart};then setenv bootfile /tftpboot/u-boot_XM51_fallback.bin;editenv bootfile;fi;setenv loadaddr 02000000&&run ${tftp,bootp or uart}&&itest ${filesize} != 0&&protect off eff20000 effffffff&&erase eff20000 +${filesize}&&cp.b ${loadaddr} eff20000 ${filesize};protect on all*		r/w
update_hwconfig[1]	Example update script to update the first sector of Flash. This updates the Reset Configuration Word & Pre-Boot, SPD data for DDR SDRAM and P3041 Microcode. Default: *askenv \"tftp,bootp or uart\";if test \"tftp\" = ${tftp,bootp or uart};then setenv bootfile /tftpboot/hwconfig_XM51.bin;editenv bootfile;fi;setenv loadaddr 02000000&&run ${tftp,bootp or uart}&&itest ${filesize} != 0&&protect off ${flashstart} +1ffff&&erase ${flashstart} +${filesize}&&cp.b ${loadaddr} ${flashstart} ${filesize};protect on all*		r/w

[1] These example scripts provide a user-friendly way to update the U-Boot main image. You can start the update using command *run update* or *run update_hwconfig*.

3.8 U-Boot Commands

The following table gives all U-Boot commands that can be entered on the XM51 U-Boot prompt. The available commands are board-specific.

You can access the command list using the *help* command (or the *?* alias. More detailed information is displayed if you enter *help* <*command*>. U-Boot supports auto completion using the <*TAB*> key.

Table 13. *U-Boot – Command reference*

Command	Description
?	Alias for 'help'
as	Assemble memory
askenv	Get environment variables from stdin
bdinfo	Print board info structure
boot	Boot default, i.e. run *bootcmd*
bootelf	Boot from an ELF image in memory
bootm	Boot application image from memory
bootp	Boot image via network using BOOTP/TFTP protocol
bootvx	Boot VxWorks from an ELF image
break	Set or clear a breakpoint
cmp	Compare memory
coninfo	Print console devices and information
continue	Continue from a breakpoint
cp	Copy memory
cpenv	Copy environment string, may be needed to forward some additional parameters to the OS
crc32	Calculate checksum
date	Get/set/reset date & time
defenv	Set environment variables to default values (use *saveenv* to store the changes)
dhcp	Boot image via network using DHCP/TFTP protocol
ds	Disassemble memory
dtt	Display temperature
echo	Echo arguments to console
editenv	Edit environment variable
eeprom	EEPROM sub-system
erase	Erase Flash memory
exit	Exit script
ext2load	Load binary file from an Ext2 file system
ext2ls	List files in a directory (default /)
fatinfo	Print information about file system

Command	Description
fatload	Load binary file from a DOS file system
fatls	List files in a directory (default /)
fdt	Flattened device tree utility commands
flinfo	Print Flash memory information
go	Start application at address *addr*
help	Print online help
i2c	I2C sub-system
iminfo	Print header information for application image
itest	Return true/false on integer compare
loadb	Load binary file over serial line (Kermit mode)
loads	Load S-Record file over serial line
loady	Load binary file over serial line (Ymodem mode)
loop	Infinite read loop on address range
loopw	Infinite write loop on address range
md	Display memory
mdc	Display memory cyclically
mii	MII utility commands
mm	Modify memory (auto-incrementing address)
mtest	Simple RAM read/write test
mw	Write to memory (fill)
mwc	Write to memory cyclically
next	Single step execution, stepping over subroutines
nfs	Boot image via network using NFS protocol
nm	Modify memory (constant address)
pci	List and access PCI Configuration Space
ping	Send ICMP *ECHO_REQUEST* to network host
printenv	Print environment variables
protect	Enable or disable Flash write protection
rarpboot	Boot image via network using RARP/TFTP protocol
rdump	Show registers
reginfo	Print register information
reiserload	Load binary file from a Reiser file system
reiserls	List files in a directory (default /)
reset	Reset the CPU
run	Run commands in an environment variable
saveenv	Save environment variables to persistent storage
saves	Save S-Record file over serial line

Command	Description
setenv	Set environment variable
setexpr	Set environment variable as the result of eval expression
showvar	Print local hush shell variables
sleep	Delay execution for some time
sntp	Synchronize RTC via network (UTC time)
source	Run script from memory
step	Single step execution
test	Minimal test like */bin/sh*
tftpboot	Boot image via network using TFTP protocol
time	Run command and output execution time
unzip	Unzip a memory region
usb	USB sub-system
usbboot	Boot from USB device
version	Print U-Boot version
where	Print the running stack

3.9 Hardware Interfaces Not Supported by U-Boot

The standard XM51 U-Boot does **not** support the following hardware interfaces:

- SATA
- OHCI for USB0..USB3 (only EHCI)

4 Organization of the Board

To install software on the board or to develop low-level software it is essential to be familiar with the board's address and interrupt organization.

4.1 Memory Mappings

Table 14. *Memory mappings – local address windows*

CPU Address Range	Size	Description
0x 0000 0000..End of RAM	512 / 1024 / 2048 MB	DDR3 SDRAM (currently up to 2 GB supported)
0x 8000 0000..9FFF FFFF	512 MB	PCIe1 memory space (USB, SATA)
0x A000 0000..BFFF FFFF	512 MB	PCIe2 memory space
0x C000 0000..DFFF FFFF	512 MB	PCIe3 memory space
Start of Flash ..EFFF FFFF	Up to 256 MB	NOR (boot) Flash (e.g., at 0x E000 0000 with 256 MB, 0x E800 0000 with 128 MB, 0x EC00 0000 with 64 MB)
0x F000 0000..F03F FFFF	4 MB	DCSR (Debug Control and Status Registers)
0x F100 0000..End of FRAM	Up to 128 KB	FRAM
0x F400 0000..F41F FFFF	2 MB	BMAN
0x F420 0000..F43F FFFF	2 MB	QMAN
0x F800 0000..F800 3FFF	16 KB	PCIe1 I/O space
0x F800 4000..F800 7FFF	16 KB	PCIe2 I/O space
0x F800 8000..F800 FFFF	32 KB	PCIe3 I/O space
0x FE00 0000..FEFF FFFF	16 MB	CCSR (Configuration, Control and Status Registers)

Table 15. *Memory mappings – PCI/PCIe master address map*

CPU Address Space	Interface	Mapped to PCI Space	Description
0x 8000 0000..9FFF FFFF	PCIe1	0x 8000 0000..9FFF FFFF (MEM)	PCI memory space (non-prefetchable)
0x A000 0000..BFFF FFFF	PCIe2	0x A000 0000..BFFF FFFF (MEM)	PCI memory space (non-prefetchable)
0x C000 0000..DFFF FFFF	PCIe3	0x C000 0000..DFFF FFFF (MEM)	PCI memory space (non-prefetchable)
0x F800 0000..F800 3FFF	PCIe1	0x 0000..3FFF (I/O)	PCI I/O space
0x F800 4000..F800 7FFF	PCIe2	0x 4000..7FFF (I/O)	PCI I/O space
0x F800 8000..F800 FFFF	PCIe3	0x 8000..FFFF (I/O)	PCI I/O space

Table 16. *Memory mappings – PCI/PCIe slave address map*

PCI Address Space	Mapped to CPU Space	Description
0x 0000 0000 . . End of RAM	0x 0000 0000 . . End of RAM	Prefetchable, snooping enabled

4.2 I2C Devices

Table 17. *I2C devices*

I2C Bus	Address	Function
0x0	0x9E	LM75 temperature sensor
	0xA0	PCIe-to-USB bridge EEPROM
	0xA2	Real-time clock
	0xA8	CPU EEPROM
	0xD0	PCIe-to-USB bridge
	0xD2	Clock generator
0x1	0xAC	Reserved for carrier board EEPROM

5 Appendix

5.1 Literature and Web Resources

- XM51 data sheet with up-to-date information and documentation:
  www.men.de/products/15XM51-.html
- XC1 data sheet with up-to-date information and documentation:
  www.men.de/products/08XC01-.html

5.1.1 CPU

- Freescale QorIQ Processing Platforms:
  www.freescale.com/webapp/sps/site/homepage.jsp?code=QORIQ_HOME
- QorIQ P4080:
  www.freescale.com/webapp/sps/site/prod_summary.jsp?code=P4080
- QorIQ P4040:
  www.freescale.com/webapp/sps/site/prod_summary.jsp?code=P4040
- QorIQ P3041:
  www.freescale.com/webapp/sps/site/prod_summary.jsp?code=P3041

5.1.2 SATA

- Serial ATA International Organization (SATA-IO)
  www.serialata.org

5.1.3 USB

- USB Implementers Forum, Inc.
  www.usb.org

5.1.4 Ethernet

- ANSI/IEEE 802.3-1996, Information Technology - Telecommunications and Information Exchange between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications; 1996; IEEE
  www.ieee.org
- Charles Spurgeon's Ethernet Web Site
  Extensive information about Ethernet (IEEE 802.3) local area network (LAN) technology.
  www.ethermanage.com/ethernet/
- InterOperability Laboratory, University of New Hampshire
  This page covers general Ethernet technology.
  www.iol.unh.edu/services/testing/ethernet/training/

5.1.5 PCI Express

- PCI Special Interest Group
  www.pcisig.com

5.1.6 I2C

- Very good introduction to the I2C bus
  www.i2cbus.com
- Wikipedia article with many references
  http://en.wikipedia.org/wiki/I2C

5.2 Finding out the Product's Article Number, Revision and Serial Number

MEN user documentation may describe several different models and/or design revisions of the XM51. You can find information on the article number, the design revision and the serial number on two labels attached to the board.

- **Article number:** Gives the product's family and model. This is also MEN's ordering number. To be complete it must have 9 characters.
- **Revision number:** Gives the design revision of the product.
- **Serial number:** Unique identification assigned during production.

If you need support, you should communicate these numbers to MEN.

Figure 6. *Labels giving the board's article number, revision and serial number*